Technology Validation of Optical Fiber Cables for Space Flight Environments

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The following article contains excerpts from a paper that was published and presented at the International Society of Optical Engineers Photonics East conference Optical Devices for Fiber Communication II, November 8, 2000, in Boston, MA. Melaine Ott and Patricia Friedberg (NASA Goddard Code 562) performed this work. The entire paper is available through SPIE proceedings Vol. 4216 or at the web site location:

http://misspiggy.gsfc.nasa.gov/tva/authored/fo_photonics.htm

Abstract

Periodically, commercially available (Commercial off the Shelf, COTS) optical fiber cable assemblies are characterized for space flight usage under the NASA Electronic Parts and Packaging Program (NEPP). The purpose of this is to provide a family of optical fiber cable options to a variety of different harsh environments typical to space flight missions. The optical fiber cables under test are evaluated to bring out known failure mechanisms that are expected to occur during a typical mission. The tests used to characterize COTS cables include: vacuum exposure, thermal cycling and radiation exposure. Presented here are the results of the testing conducted at NASA Goddard Space Flight Center on COTS optical fiber cables over this past year. Several optical fiber cables were characterized for their thermal stability both during and after thermal cycling. The results show how much preconditioning is necessary for a variety of available cables to remain thermally stable in a space flight environment. Several optical fibers of dimensions 100/140/172 microns were characterized for their radiation effects at -125°C using the dose rate requirements of International Space Station. One optical fiber cable in particular was tested for outgassing to verify whether an acrylate coated fiber could be used in a space flight optical cable configuration.

Introduction

This is the fifth paper in a series of publications on the subject of characterization of commercial optical fiber and optical cables for space flight. The objective of these publications is to provide information on the correct environmental usage of commercial cables for space flight through characterization testing to typical space flight environmental parameters. Several tests are used as a technology validation method to determine if an optical cable is suitable for a typical space flight environment. Included in this validation testing are outgassing testing, thermal testing and radiation testing. Vibration testing is also used as a technology validation test but data from this type of testing is not included in this paper.

In most cases, all materials used on space flight hardware are evaluated for outgassing characteristics in a vacuum environment to ASTM 595 (% Total Mass Loss, %TML must be less than 1%).5 If a material passes the ASTM 595 test then the material is considered acceptable for usage in a vacuum environment. A comprehensive database is available via a NASA GSFC web site. In some cases when a material is known to outgas in a vacuum environment, the potential for usage still exists if the outgassing occurs in an area of the unmanned portion of a space craft such that these materials could not degrade the

performance of any existing systems. Acrylate coatings used as protection on optical fiber are well known as "outgassers" and therefore are usually prohibited from space flight missions. However, acrylate coating used inside of a cable configuration was evaluated by Lockheed Martin to verify whether the acrylate coating added to the collected materials or mass loss. The testing showed that this configuration was acceptable by ASTM-595. The result of this testing was never verified at GSFC until now.

Thermal stability of optical cables is examined in two ways. The first is to examine the optical stability of fiber optic cable configuration given a changing thermal environment or during thermal cycling. The second is to examine the total amount of cable component shrinkage after exposure to a changing thermal environment or after thermal cycling. Both tests are used to determine if a cable is suitable for space flight. Presented here are results from testing using a generic thermal environment of -55°C to +125°C.

Lastly, of the subjects presented here, total ionizing dose radiation testing is used as a technology validation method of determining which fiber cable is suitable for space flight environment usage. The data presented is from testing using the International Space Station environment at two different dose rate exposures while at a temperature of -121°C. In most cases, low temperature during radiation exposure, represents the worst case for radiation induced attenuation for cable configurations containing typical germanium doped 100/140 micron optical fiber. At colder temperatures optical fiber is less likely to anneal and recover from the color centers generated as a result of radiation exposure. The test results from cold temperature radiation exposure of three optical fibers are discussed here.

Conclusion

Examined here were several optical fiber cables and optical fiber for their suitability in typical space flight environments. The W.L. Gore FON1008 cable was tested with acrylate fiber inside for its suitability in a thermal vacuum environment. The W.L. Gore FON1004, the Brand Rex OC1614 and OC1008 and the Northern Lights H06 and HL1 made for RIFOCS were examined for thermal stability for the parameters of length shrinkage and optical stability. Lastly three 100/140/172 polyimide, carbon coated optical fibers made by Lucent SFT were tested for their suitability of use in the ISS space radiation environment at -125 °C.